NC PROGRAMMING

Numerical Control (NC) refers to the method of controlling the manufacturing operation by means of directly inserted coded numerical instructions into the machine tool. It is important to realize that NC is not a machining method; rather, it is a concept of machine control. Although the most popular applications of NC are in machining, NC can be applied to many other operations, including welding, sheet metalworking, riveting, etc.

Advantages of NC

The major advantages of NC over conventional methods of machine control are as follows:

i. Higher precision
ii. Machining of complex three-dimensional shapes
iii. Better quality
iv. Higher productivity
v. Multi-operational machining
vi. Low operator qualification

Types of NC systems

Machine controls are divided into three groups:

i. Traditional numerical control (NC)
ii. Computer numerical control (CNC)
iii. Distributed numerical control (DNC)

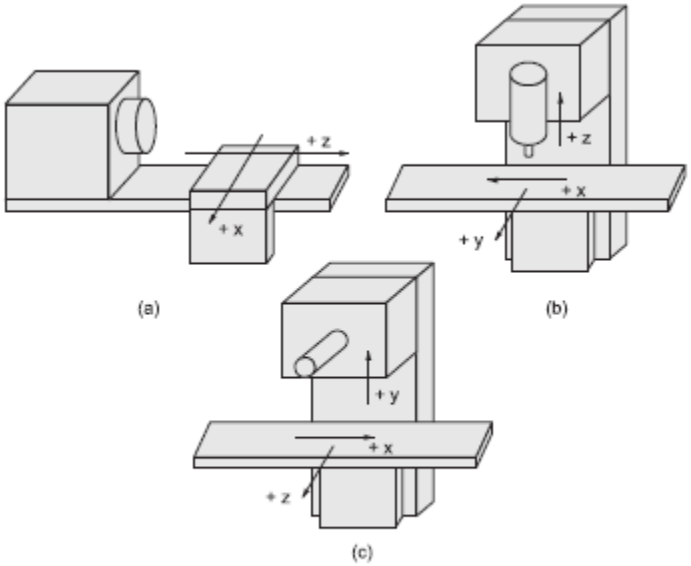
The original numerical control machines were referred to as NC machine tool. They have hardwired control whereby control is accomplished through the use of punched paper or plastic tapes or cards.

CNC refers to a system that has a local computer to store all required numerical data. While CNC was used to enhance tapes for a while, they eventually allowed the use of other storage media, magnetic tapes and hard disks. The advantages of CNC systems include but are not limited to the possibility to store and execute a number of large programs especially if a 3 0r more dimensional machining of complex shapes is considered, to allow editing of programs, to execute cycles of machining commands, etc.

The development of CNC over many years along with the development of local area networking has evolved in the modern concept of DNC.DNC is similar to CNC except a remote computer is used to control a number of machines. An off-site mainframe host computer holds programs for all parts to be produced in DNC facility. Programs are downloaded from the mainframe computer, and then the local controller feeds instructions to the hardwired NC machine.

Controlled axes

NC system can be classified on the number of directions of motion they are capable to control simultaneously on a machine tool. Each free body has six degree of freedom, three positive or negative translations along x, y, and z-axis, and three rotations clockwise or counter clockwise about the axes. Commercial NC systems are capable of controlling simultaneously two, two and half, three, four and five degrees of freedom, or axes. The NC systems which control three linear translations (#-axis systems) or three linear translations and one rotation of the worktable (4-axis systems) are the most common.

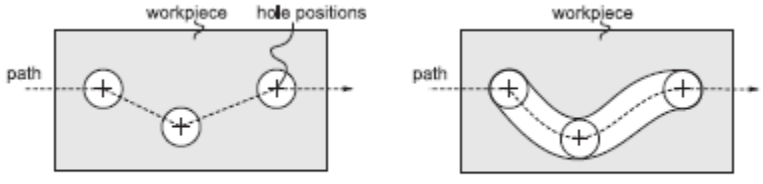


Identification of controlled axes for a lathe (a), vertical spindle milling machine (b), and horizontal spindle milling machine (c).

Point-to-point vs. contouring systems

Point-to-point is a NC system, which controls only the position of the components. In this system, the path of the component motion relative to the workpiece is not controlled. The travelling between different positions is performed at the transverse speed allowable for the machine tool and following the shortest way.

Contouring NC systems are capable of controlling not only the positions but also the component motion, that is, the travelling velocity and the programmed path between the desired positions.



Schematics of point-to-point (*Left*) and contouring (*Right*) NC systems.

NC program

NC program consists of a sequence of directions that causes an NC machine to accomplish a certain operation. It describes the sequence of actions of the controlled NC machine. These actions include but are not limited to:

i. Component movements including direction, velocity and positioning.
ii. Tool selection, tool change, tool offsets and tool corner wear compensation
iii. Spindle rotation and spindle rotation speed
iv. Cutting speed for different diameters in turning
v. Application of cutting fluids.

A part program is simply a NC program used to manufacture a part. Part programming for NC may be performed manually or by the aid of a computer. Many programming languages have been developed for part programming. One of the most popular is called APT (Automatically Programmed Tools). Many variations have been developed including ADAPT (Adaptation of APT), EXAPT (a European flavor of APT), UNIAPT (APT controller for smaller computer systems), etc.

NC programming for complex parts is generated using advanced computer programs (CAD/CAM programs) which create automatically the machine code (so called G-code) in a graphic environment. Machine code is also largely used for manual part programming of simple shapes.

REVIEW QUESTIONS

1. What is numerical control?
2. State the advantages of NC programming
3. Differentiate between point-to-point and contouring systems
4. Enumerate the types of NC systems